LA2000 GEN. 2

Linear Servo Amplifier

USER'S MANUAL

Motion Control Systems, Inc.
New River, Virginia

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Part 1

IMPORTANT SAFETY NOTICES

1.1 Safety Notices / Avis de sécurité

The following conventions are used to illustrate important safety information in the manual.

Les conventions suivantes sont utilisées pour illustrer les informations de sécurité importantes contenues dans le manuel.

WARNING: Alerts reader of conditions and/or procedures that could result in personal injury or death.

AVERTISSEMENT : Indicateur de conditions et/ou de procédures pouvant entraîner des préjudices corporels ou la mort.

CAUTION: Calls attention to conditions and/or procedures which, if not followed, can result in permanent damage to equipment.

ATTENTION : Attire l'attention sur des conditions et/ou des procédures qui, si elles ne sont pas respectées, peuvent entraîner des dommages permanents aux équipements.

NOTE: Points out useful or important information to the reader.

NOTE : Souligne des informations utiles ou importantes pour le lecteur.

1.2 Safety Ground / Prise de terre de sécurité

This product must be grounded. The power cord supplied with the product is for 115 VAC outlets. If the user wishes to provide a different cord for 230 VAC, the cord must have a ground connection. In addition, any device (e.g. motor, control device, etc.) connected to this system must be grounded.

Ce produit doit être mis à la terre. Le cordon d'alimentation fourni avec le produit est conçu pour les prises 115 V CA. Si l'utilisateur souhaite utiliser un cordon différent adapté à une alimentation 230 V CA, ce dernier doit pouvoir être relié à la terre. Par ailleurs, tout élément (par exemple, moteur, dispositif de commande, etc.) connecté à ce système doit être mis à la terre.

WARNING: Operation without proper grounding can result in a potentially fatal electric shock. Any accessible component (e.g. case, switches, etc.) or peripheral device is to be considered "live" under this condition.

AVERTISSEMENT : Tout fonctionnement sans une mise à la terre adéquate peut entraîner un choc électrique potentiellement fatal. Tout élément accessible (par exemple, boîtier, interrupteurs, etc.) et tout dispositif périphérique doivent être considérés comme étant sous tension.

1.3 Hazardous Voltages Warning / Avertissement d'une tension dangereuse

WARNING: Dangerous voltages exist at several places within the enclosure. Disconnect power before and during any disassembly or servicing. Only qualified personnel should service this product.

AVERTISSEMENT : Des tensions dangereuses existent à différents emplacements du site. Couper l'alimentation avant et pendant toute manipulation ou toute opération d'entretien. Seul du personnel qualifié peut assurer l'entretien de ce produit.

WARNING: Dangerous voltages exist at the motor power terminals when the drive has power applied. Disconnect power and exercise caution when connecting to these terminals.

AVERTISSEMENT : des tensions dangereuses existent au niveau des bornes du moteur lorsque la transmission est alimentée. Couper l'alimentation et rester vigilant lors de la connexion à ces bornes.

1.4 Life Support Policy / Politique de survie

Motion Control Systems, Inc. products are not authorized for use as critical components in life support systems without the expressed written consent of the President of Motion Control Systems, Inc.

A critical component is any component whose failure or malfunction could result in the failure of the life support system or in the reduction of its safety or effectiveness.

Les produits Motion Control Systems, Inc. ne peuvent pas être utilisés comme éléments critiques dans des systèmes de survie sans l'autorisation écrite expresse du président de Motion Control Systems, Inc.

Un élément critique est un élément dont la défaillance ou le dysfonctionnement pourrait entraîner la défaillance du système de survie ou la limitation de sa sécurité ou de son efficacité.

1.5 Other Notices / Autres avis

WARNING: Do not operate this system in explosive atmospheres.

AVERTISSEMENT : ne pas utiliser ce système dans des atmosphères explosives

CAUTION: The voltages applied to the LA amplifier must not exceed the maximum stated voltages. (See Section 9.1)

ATTENTION : la tension appliquée à l'amplificateur LA ne doit pas excéder les tensions maximum définies (voir la section 9.1).

WARNING: The AC input power is double pole/neutral fused.

AVERTISSEMENT : l'alimentation CA dispose d'un fusible bipolaire/neutre.

CAUTION: See Part 9 for Fuse Ratings.

ATTENTION : Voir la Partie 9 pour le classement de fusible.

NOTE: This manual uses the terms "Amplifier", "Controller", "Motor Drive", and "Motor Controller" interchangeably.

NOTE : ce manuel utilise les termes « amplificateur », « contrôleur », « moteur » et « commande moteur » de manière interchangeable.

Part 2

GENERAL

2.1 Introduction

The LA2000 is a four quadrant velocity servo amplifier intended to control three phase permanent magnet synchronous motors (commonly called brushless DC motors, since some of their characteristics are similar to ordinary DC motors). The LA2000 motor controller uses a very "quiet" linear power stage and is intended for applications where electromagnetic interference or acoustical noise must be kept to a minimum.

Under normal operation, a brushless motor controller must "know" the position of the rotor in order to commutate the motor to produce torque. The LA2000 obtains rotor position information from a quadrature encoder or Hall Effect sensors. The LA2000 can also be optionally configured, by MCS, to use an external commutation source with current requests fed directly into the amplifier (known as Sine/Sine+120 operation).

Systems are intended for computer control through a high level command syntax. This feature allows them to be easily integrated into computer controlled testing or manufacturing equipment. For other applications, see Section 5.2 (Hardware Interface).

The motor controller unit is intended for cabinet or panel mounting. See Section 3.2, Mounting, for a mounting diagram.

2.2 Warranty

Motion Control Systems, Inc. (MCS) warrants that all products it manufactures shall be free from defects in materials and workmanship for a period of one (1) year from the date of shipment, provided that such products have been subjected to proper and normal use, and further provided that MCS receives written notice from the purchaser setting forth the nature and extent of the defect within the warranty period. The obligations of MCS under this warranty are limited to, at its option, the repair or replacement, free of charge, of any product covered by this warranty that has been returned with prior written consent to MCS, or as it may direct, transportation charges prepaid by the purchaser.

Motion Control Systems, Inc. (MCS) reserves the right to void this warranty at any time if any product is altered, tampered with, modified, repaired or serviced by any unauthorized person or company, without prior written approval from MCS.

MCS takes no responsibility for any damage to products if unauthorized alterations or modifications were performed without prior written consent from MCS.
MCS shall, in no event, be liable for any breach of warranty in an amount exceeding the purchase price, nor for any special, consequential, or incidental damages.

This warranty is in lieu of any and all other warranties, expressed, implied, or statutory including implied warranties of merchantability or fitness.

2.3 Field Service

Normal procedure requires that defective products be shipped prepaid and with prior written consent to MCS for repair. However, under certain extreme circumstances and at the purchaser's request, MCS can provide on site service. Contact the MCS sales department to arrange a service visit. A purchase order must be issued and received by MCS prior to departure of MCS service personnel.

Part 3

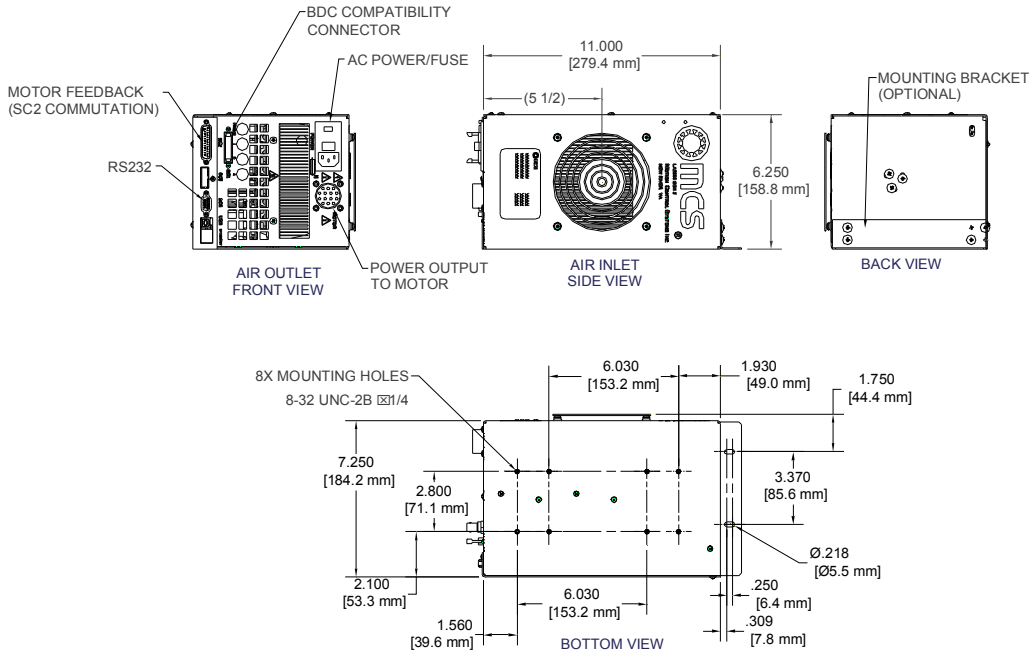
INSTALLATION

3.1 Unpacking

Remove the unit from its shipping container. All units should be lifted and handled from the back (mounting panel surface). Inspect the unit for shipping damage. Do not attempt to operate the unit if it has been damaged, or if it has been configured improperly. Instead, call MCS.

3.2 Mounting

The amplifier mounts through tapped holes on the bottom of the unit. The holes are for screws size 8-32. Mounting is also available with an optional mounting flange on one end of the amplifier. Do not block the front (air exhaust) or the side (air inlet) of the controller. All connections to the amplifier are on the front on the unit, therefore be sure to leave enough room at the front of the unit for wiring. Below is a diagram of the mounting hole locations. See Drawing #1405210 for a more detailed drawing.



NOTE: The amplifier should be mounted and positioned so that access to the main power switch is not restricted.

NOTE: Amplifier protection devices may be impaired if the LA amplifier is not operated or mounted according to the recommendations in this manual.

3.3 Ambient Conditions

Select a location free of excessive dust, coolants, vibration, corrosives, condensation, flammable materials, etc. Select a location having ambient temperature between zero and 40 degrees C, and humidity between 5% and 80% (non-condensing). Although the motor controller is thermally protected, ambient temperature should be kept as low as practical, since high temperatures can degrade performance and reliability.

3.4 Air Flow Requirement

The motor controller has a built-in fan for cooling, which exhausts out of the front of the unit. Do not obstruct the fan, or any other vents, as this may cause the unit to overheat. MCS recommends maintaining at least 1" (2.54cm) minimum clearance around fan intake and air exhausts.

Part 4

ELECTRICAL SYSTEM WIRING AND ADJUSTMENT

Use the relevant System Wiring Diagram (listed in Section 10) included in this manual as a reference when connecting the system.

CAUTION: Make all connections to the system with the power OFF, unless otherwise instructed.

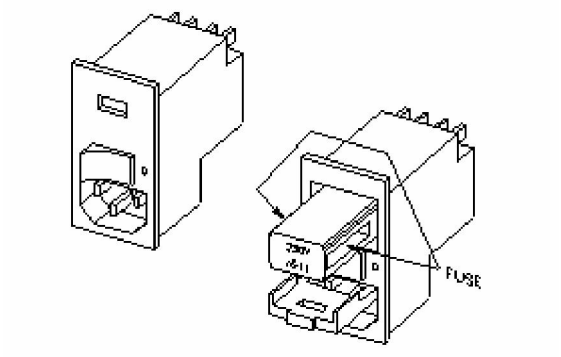
ATTENTION : procéder à toutes les connexions au système avec l'alimentation coupée, sauf instruction contraire.

4.1 Input Power

4.1.1 Selecting Input Voltage

An IEC connector is provided on the front of the unit for power entry. Units are field configurable for 115/230 VAC operation through the power entry module. To change the input voltage configuration, pull down the top latch of the module and remove the fuse holder/voltage selector. Put the fuse holder/voltage selector back in the module with the desired input voltage reading right side up through the window. Below is a drawing of the module with the latch closed and opened. Part 9 contains information on fuse selection.

NOTE: If 230VAC input power is used, fuses of lower current rating must be used. See Part 9 for the appropriate fuse sizes based on input voltage.



4.1.2 Input Voltage/Current Ratings

Please refer to Part 9 (Specifications) for detailed input voltage and current requirements.

4.2 Output Power

4.2.1 Motor Connections (*for motors manufactured by MCS*)

Motors manufactured by MCS will have leads that are colored or coded as follows:

Wire Color	Phase Name
White	Phase W
Black	Phase V
Red	Phase U

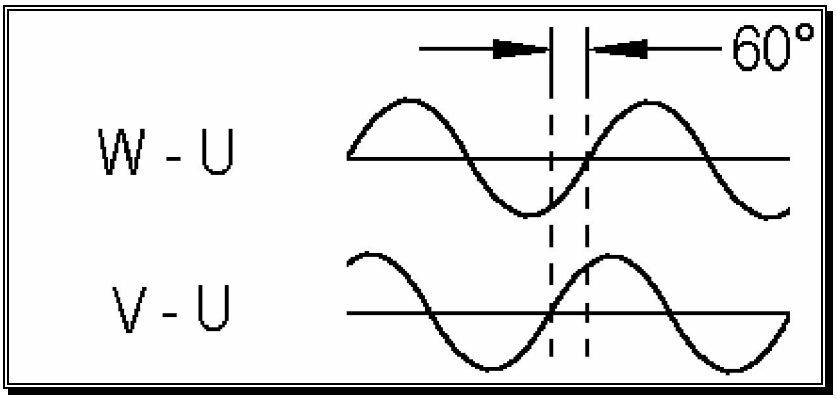
Some motors manufactured by MCS will have all phase windings available for connection. In this case, the motor has six leads; two per phase. This permits the windings to be connected in either wye or delta connection. Such a motor will have its leads labeled as 1F, 1S, 2F, 2S, 3F, and 3S.

WYE	
AMP	**MOTOR**
W	Phase W: 3S
V	Phase V: 1S
U	Phase U: 2S
	Connect 1F + 2F + 3F together

DELTA	
AMP	**MOTOR**
W	Phase W: 2F + 3S (connect together)
V	Phase V: 3F + 1S (connect together)
U	Phase U: 1F + 2S (connect together)

4.2.2 Motor Connections (*for motors* not *manufactured by MCS*)

Designate the motor leads as "U," "V," and "W" such that the sequence U-V-W causes CW (clockwise) rotation of the motor shaft when looking at the motor from the non-lead side. The lead side is the side of the motor at which the motor lead wires exit. If you view the motor output voltages (Back-EMF) of the motor while it is disconnected from the controller and spun clockwise by hand, the output on an oscilloscope should look as follows:



4.2.3 Motor Power Connection

The power to the motor is supplied through a CPC plastic connector on the front panel. This connector is intended for connection to three-lead motors. The following table shows the pin out for the motor power connector.

Motor Power Connector

Pin #	3-LEAD MOTOR Phase Name
1	Phase W
6	Phase V
8	Phase U
14	GROUND

Mating Connector: Tyco/AMP P/N: 206044-1
Mating Pins: Tyco/AMP P/N: 66361-2 (14-18 AWG wire) or 66103-2 (20-24 AWG wire)

4.3 Motor Feedback (Commutation) Wiring

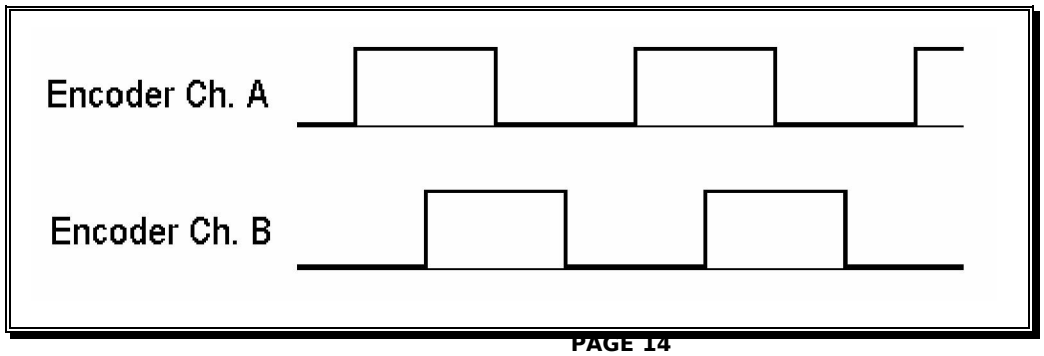
4.3.1 Encoder Wiring

The amplifier has a 5V, 250 mA (max) power supply available for powering an encoder (and motor Hall Effect Devices – refer to section 4.3.2). The encoder connects to connector SC2 on the front of the unit. Connections are shown below in the table. The LA2000 can accept differential or single-ended TTL or 5V CMOS level encoder signals. An MCS-installed option is available for use with a sinewave output (analog) encoder. Contact MCS for more information on this option, if needed. Use an encoder with differential outputs whenever possible, to reduce the effects of ambient electromagnetic interference. If a single-ended output encoder is used, treat the A-, B-, and INDEX- inputs as "No Connect" pins. Use the **CONFIG?** command to determine if your system is configured for single ended or differential inputs. See Section 5.1.2.2 Commands for the Configuration Mode, if you need to change the configuration.

Encoder Connections Table

+5V Supply	1
Encoder Channel A+	2
Encoder Channel B+	3
Encoder Index +	4
Logic Common	9 or 25
Encoder Index -	12
Encoder Channel A-	20
Encoder Channel B-	21
Shield	24

To determine the correct convention of the A and B inputs, apply power to the encoder and rotate the shaft or rotor in the CW direction, as viewed from the end of the motor opposite the motor lead exit. The A input should lead the B input by transitioning from 0 to 1 while B is at 0. To determine whether the system is set up properly, rotate the motor in the CW direction. While the motor is rotating, issue the **DIR?** command to the serial interface. If the system responds with "CW" then the encoder is wired properly. If it responds "CCW," switch the encoder A and B inputs. It is important that the command is issued while the spindle is rotating smoothly, because the motor momentarily reversing could result in the wrong status reported back. For LA2000 drives that do not have the optional BNC encoder outputs, a breakout fixture can be connected to the SC2 connector to view the A and B encoder channels.
The correct encoder outputs for CW rotation (as viewed at the input of SC2):



4.3.2 6-Step Hall Effect Device Wiring (*for motors manufactured by MCS*)

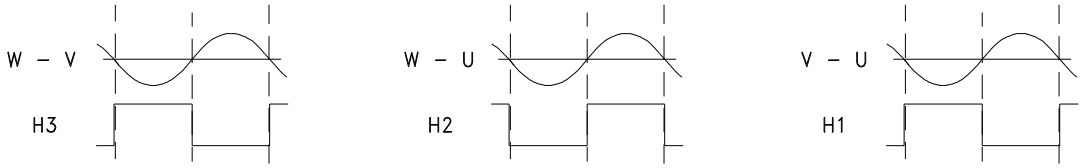
The LA motor controller has a 5 volt, 250mA (max.) power supply available for powering Hall Effect sensors (and an encoder – refer to section 4.3.1). The sensors connect to connector SC2 (DB25M) on the front panel.

6 Step Hall Effect Wiring Connections (for MCS motors)

DESIGNATION	WIRE COLOR	SC-2 PIN #
+5V Supply	Red	1
Logic Common	Black	9 or 25
Hall Sensor 1	Yellow	15
Hall Sensor 2	Green	16
Hall Sensor 3	White	17
Shield	----	24

4.3.3 6-Step Hall Effect Convention (*for motors* not *manufactured by MCS*)

Hall Effect devices are used by the controller to determine the position of the rotor with respect to the stator. The proper phasing of the Hall sensors is essential to proper motor operation. To determine the correct phase, rotate the motor CW and display the waveforms described below on an oscilloscope to determine whether the Hall Effect devices are properly phased. When displaying the waveforms on a scope, the second phase shown is connected to probe GND (e.g., when displaying "W – V", place the probe TIP on "W" and probe GND on "V"). The diagram below corresponds to the LA2000 default commutation angle setting (270 degrees).



<u>NOTE:</u> Hall Effect devices have open collector outputs which must be connected to a +5VDC power supply through a suitable "pull-up" resistor. LA series drives contain internal pull-up resistors. When disconnected from the drive, the Hall Effect outputs will not switch. Use 2.2 KΩ pull-up resistors to +5VDC to observe device switching.

4.4 Initial Adjustments

Before attempting to operate the system, some adjustments to the motor and to the controller may be necessary. Read each section thoroughly before attempting each adjustment. In particular, understand the Motor Phase Sequence Convention (Section 4.2.2) before making the adjustments. Most motor controllers provided as systems will not need adjustment. However, MCS recommends that the user verify that the adjustments meet the application's requirements.

4.4.1 Commutation Adjustment for Encoder-Only Systems

Encoder-Only commutation is specified using the **TYPE:07** command from the configuration menu. Systems using Hall Effect devices do not require encoder adjustment. Commutation adjustment requires the alignment of the encoder index to an optimal angular location with respect to the motor. This adjustment allows the system to use the minimum current to produce a given torque.

NOTE: **If the motor and encoder were shipped as a completely assembled system, MCS has already made the adjustment. In this case, further adjustments will not be necessary.**

NOTE: **A "breakout fixture" on connector SC2 is helpful for this adjustment, if the drive is not equipped with the optional BNC encoder outputs.**

CAUTION: Use care when making this adjustment, since encoders are delicate instruments. An incorrect adjustment of the index could cause reduced torque and motor heating.

ATTENTION : réaliser ce réglage avec soin car les codeurs sont des instruments délicats. Un mauvais réglage de l'index peut entraîner une réduction du couple et une surchauffe du moteur.

The index input is edge-sensitive and will detect active-high or active-low index pulses. The index input will detect the falling edge for CW motor rotation or the rising edge for CCW rotation. (See Section 4.2.2 for motor phase sequence convention). The index can be set mechanically (provides interchangeability) or adjusted electronically (requires no mechanical adjustment but motors and controllers will not be interchangeable).

To mechanically set the index (FIRMWARE VERSIONS V3.17 and higher):
Power up the system and rotate the motor shaft (or rotor). Using an oscilloscope connected to SC2, Pin 4, or the Index output BNC connector, you should observe a once-per-revolution index pulse. Set the motor shaft position near the present index. This will minimize the adjustment required. ***Verify that the direction is set to CW and that the torque setting has been reduced to around 10%. (ANALOG TORQUE CONTROLLED SYSTEMS- SEE NOTE ON NEXT PAGE)*** Enter the encoder set-up mode (**SETZEROPOS**). Enable the amplifier (**EN**). The motor will seek a position and lock there. Loosen the encoder housing and rotate the encoder such that the index pulse is set to this locked position. Tighten the encoder housing and test the adjustment by turning the motor a few degrees. Verify that it returns to the index position. To return the drive to normal operation, disable the amplifier (**DIS**). Verify that the LA2000 operates normally. This method allows any LA2000 Gen 2 to operate with any motor/encoder

combination as long as this procedure has been followed for the given motor/encoder and the **ANGLE** parameter in the LA2000 is set the same.

NOTE FOR ANALOG TORQUE CONTROLLED SYSTEMS: ***Use a negative polarity command voltage (equivalent of requesting CW direction) when following the above procedure.***

If using a negative polarity voltage command is not possible, follow the procedure using a positive torque command, and then change the angle setting by 180 degrees before attempting to run the motor. For example, if the ANGLE was set to 270 degrees while locking the motor, set the ANGLE to 90 and WRITE to eeprom before running the motor.

To electronically set the index:

It is also possible to set the index electronically by measuring the phase angle, while rotating clockwise, between the positive-going zero crossing of the motor Back-EMF (phase W with respect to U) and the index pulse. This measured angle may be programmed in with the angle command. Note that if this method is used, the angle setting will be specific to the individual motor/encoder combination it was measured on.

4.4.2 Commutation Adjustment for Hall Effect + Encoder Systems

Hall Effect + Encoder commutation is specified using the **TYPE:06** command from the configuration menu. To eliminate motor position uncertainty at initial system power-up (typical of encoder-only systems that require the index pulse to determine position), Hall Effect devices may be used in conjunction with the encoder. The amplifier commutates using Hall Effects initially, learns the position of the encoder index pulse, and then automatically switches to encoder feedback for commutation. During this initial period, one or more motor current electrical cycles will occur before the switch to encoder commutation is made. Mechanical revolutions are related to electrical revolutions in the following way:

$$\left(\frac{poles}{2}\right) electrical\ cycles = mechanical\ revolutions$$

When using a motor with Hall Effect devices and an encoder, this configuration is specified using the **TYPE:06** command from the configuration mode. It is normally not necessary to adjust the timing of the Hall Effect sensors, but certain occasions warrant it (changing between WYE and DELTA motor wiring, for example). To adjust the timing on the Hall sensors use the **ANGLE:XXX** command from the configuration mode. The standard Hall Effect timing angle on motors manufactured by MCS is 270. This applies to 3 lead motors and 6 lead motors wired in WYE. MCS-manufactured 6 lead motors wired in DELTA should use an angle setting of 300 degrees. To adjust in the CCW direction, use a number slightly less than nominal. To adjust in the CW direction, use a number slightly larger. For bi-directional applications requiring a different angle for each direction, use the **OFFSET:XX** command (if available – not all LA configurations use this command.) For example, you may find that better performance is achieved in the CW direction with an ANGLE of 285 while in the CCW direction better performance is realized with an ANGLE of 255. This would be require **ANGLE:270** and **OFFSET:15** to be programmed in the unit. This adjustment cannot be made while the motor is running. To adjust,

disable (**DIS)** the controller and enter the desired value. If experimenting, be sure to change the angle in small increments, as large changes could cause improper system operation and excessive motor and amplifier heating. When you find the correct value, be sure to save the setting by entering the configuration mode and writing to the EEPROM with the **WRITE** command.

Angle offset is not available on drives configured for stop and lock operation (LOCKMODE1).

WARNING: MCS strongly recommends against adjusting this value since improper adjustment can cause reduced torque, motor heating, amplifier heating or a runaway condition. When modifying the ANGLE **or** OFFSET**, use the** OVERSPEED **function and a lower torque limit (**TORQ:XXX**) to prevent problems that may result from improper motor commutation**.

AVERTISSEMENT : MCS recommande fortement de ne pas régler cette valeur car un réglage incorrect peut entraîner une réduction du couple, une surchauffe du moteur, une surchauffe de l'amplificateur ou des conditions d'emballement. En cas de modification de ANGLE **ou de** OFFSET**, utiliser la fonction** OVERSPEED **et une limite de couple inférieure (**TORQ:XXX**) pour éviter tout problème pouvant résulter d'une commutation de moteur incorrecte.**

4.5 Encoder Outputs

MCS offers an option that provides a set of BNC jacks for encoder outputs as well as the command frequency input. The BNC output jacks are marked A, B, and I to correspond to the encoder channels A, B, and Index respectively. The outputs are TTL level and are capable of driving 50Ω impedances. Because of the high current drive capability of these outputs, it may be necessary to resistively terminate these signals at the receiving electronics to eliminate signal ringing. If the receiving electronics do not provide a low impedance load, a resistor (50-500 ohms) should be connected between the output and ground at the load end of the cable.

4.6 Serial (RS-232) Communications Wiring

The serial interface conforms to EIA RS-232C specifications, using a DE-9 (female) connector on the front of the unit (labeled "SC5 RS232"). Communication parameters for the system are 8 data bits, 1 stop bit, and no parity. The default baud rate is 9600 baud. LA series amplifiers do not use any type of hardware or software handshaking. If hardware handshaking is enabled on the host system, those pins must be disabled. The amplifier requires a null modem cable in order to communicate. If one is not available, Pins 2 and 3 should be crossed in the cable.

Amp DE9 Female Connector	Signal Name	Connect To Terminal Standard Serial Port		Serial Port Function
		DE9	DB25	
1	Ground	-	1	Shield
2	Receive	3	2	Transmit
3	Transmit	2	3	Receive
4	Handheld Term. RX	-	-	N/A
5	Ground	5	7	Ground
6	At Zero Speed	-	-	N/A
7	Handheld Term. TX	-	-	N/A
8	At Speed	-	-	N/A
9	+5V	-	-	N/A

8 Data Bits, 1 Stop Bit, No Parity

A reference is available in Part 5 that details the controller command protocol.

Since handshaking is not used in the LA, some pins on the DE9 connector are allocated for other LA uses. Pins 4 and 7 are used for Receive and Transmit signal connection to a remote hand-held terminal (optional) that may be used to control the LA amplifier. Pins 6 and 8 are used to indicate when the motor connected to the LA is at zero speed, or has reached the target velocity ("at speed"). The "At Speed" and "At Zero Speed" signals are TTL level. "At Speed" is active high. "At Zero Speed" is active low.

4.7 USB and Ethernet Communications Wiring

The LA2000 is equipped with USB and Ethernet interfaces. The USB interface emulates a hardware RS-232 serial port and uses a standard Type B connector. The 10/100 Ethernet interface provides a command based Telnet interface that emulates the RS-232, as well as a graphical web server interface. The connector is a standard RJ-45 connector. Please see the commands reference for information on setting the IP address and other parameters. It is required that all devices on the network have a unique IP address. The drive is intended to be used with RFC-1185+ standard compliant telnet clients for telnet functionality, and/or a web browser (Mozilla recommended) for webserver functionality. Enter the drive's IP address in your web browser address bar to access the web interface to the drive. Please see the documentation included on the user manual CD for installation of the USB drivers, if needed.

4.8 Optional 20 Pin Ribbon / BDC Compatibility Connector

An additional connector may be installed on the LA2000, for use with certain legacy systems or to interconnect customer electronics to important I/O signals. This connector provides isolated frequency and direction inputs as well as non-isolated outputs for all encoder signals and "At Speed" status. Contact MCS for more information regarding use of this connector. The pin-out is as listed below:

Pin	Function	Pin	Function
1	Isolated +5V Input	2	Isolated +5V Input
3	*Future Use TBD	4	Command Frequency Input (Isolated)
5	*Aux Fault Input	6	Direction Input (Isolated)
7	Isolated Common Input	8	Isolated Common Input
9	*Enable Input (tied to pin 10)	10	*Enable Input (tied to pin 9)
11	+5V	12	+5V
13	Encoder A Channel Output	14	**At Speed Output / Fault Output
15	Index Output	16	Encoder B Channel Output
17	Logic Common	18	Logic Common
19	*Analog Request+ / Sine Input (Configuration dependent)	20	*Analog Request- / Ext. Tach / Sine+120 Input (Configuration dependent)

* These signals were not originally used on the BDC drives. They were added on the LA2000 to allow the same connector to be used for other applications. The analog request input is normally configured for a 0 to +/- 10V single-ended signal referenced to logic common. The analog request input can optionally be configured, by MCS, for a differential signal input, with a maximum differential input voltage of +/- 10V between pins 19 and 20.

** Pin 14 functions as the "Fault status" (Faulted = High) output only if the drive is configured for analog torque control. In Frequency-Lock-Loop control mode, this pin is the "At Speed status."

4.9 Optional High Frequency PECL Connector / AUX PLL Option

MCS offers an option to allow a high frequency "master clock" signal as the command frequency reference. This signal is differential PECL level and input on a special connector. This command can then be divided down by a programmable divisor to produce a command frequency equal to either the required speed command for the encoder rate (if it is evenly divisible) or a one pulse per rev signal (if it is not equally divisible). The option also includes an auxiliary PLL circuit which is used to multiply the single pulse per rev signal to the required speed command for the encoder rate. This option also includes analog I/O for velocity error output and an auxiliary analog summing junction input. A TTL level index output is also provided on this connector. The connector is a 0.050" pitch 26 pin header. This option is application specific and is not compatible with all encoder line counts and all operating speeds. Please contact MCS for more information.

Part 5

USER INTERFACES

5.1 Software Interface

5.1.1 Command Definition

Commands are ASCII strings, terminated by a carriage-return character (ASCII 0DH). Multiple commands are entered as one string by separating them with semicolons. The maximum command string length is 511 characters. A carriage-return at the end of the command string will initiate the action of decoding the entire command string.

If a command string cannot be accepted due to transmission or syntax errors, the system will respond with an error code followed by a "?" and a line feed character (ASCII 0AH). Descriptions for the error codes are given in section 5.3. If the command string is accepted, the system will respond with a line feed character.

5.1.2 Command Summary

Commands are not case-sensitive. In the following descriptions, any quotes shown are not part of the commands or responses. Commands are divided into two sections, where each represents a different mode of operation (**Normal and Configuration**).

5.1.2.1 Commands for Normal Mode

AOT?	Queries the amplifier over temperature status.
ACCEL:XXXXX	Sets the commanded acceleration rate in RPM/sec. XXXXX is a number from 1 to 65535. Note that 0 is invalid. Only valid if ramping is enabled.
ACCEL?	Returns the value of **ACCEL:XXXXX** command.
ATSPD?	Returns a "**YES**" if the motor is rotating at the correct speed as set by the **SPD:XXXXX** command.
CCW	Commands counterclockwise rotation.
CLAMP	Causes the motor or spindle chuck clamp to lock down onto the work piece or disk.
CLAMPRUN	Performs a CLAMP and a RUN command in sequence.

CLEARZEROPOS Exits the encoder set-up state and returns the amplifier to operation mode.

CONFIG? Responds with system configuration information in the following form:

Speed:
Torque:
Direction:
Acceleration:
Acceleration: (on/off)
Topspeed:
Stop Speed:
Frequency: (internal/external)
System Control: remote
Polecount:
Encoder Linecount:
Commutation Type:
Angle: Angle Offset:
Deceleration:
Encoder Type: (Differential / Single-ended)

CONFIGURE Enters the Configuration Mode.

CURRENTQ Displays approximate peak motor current in Amps.

CW Commands clockwise rotation.

DECEL:XXXXX Sets the commanded deceleration rate after a stop command is given or the speed request is reduced to a lower speed. XXXXX is a number in RPM/sec between 1 and 65535. Only valid if ramping is enabled.

DIR? Requests direction status. Returns CW for clockwise and CCW for counterclockwise.

DISABLE or DIS Disables the unit. Similar to STOP, except the motor coasts to zero speed, rather than being actively decelerated to a stop.

DISFAULTS? Responds with which faults are disabled.

DISFLTQ? Lists all faults in a text display and indicates whether each fault is enabled or disabled.

DUMPX These commands allow the user to view the internal parameter settings of the EEPROM. X is a number from 1 to 5, representing the 5 pages of information.

ENABLE or **EN** Enables the controller and commands the motor to accelerate to the requested speed. Same as RUN.

ENABLE? Requests the enable status. The system responds with an ASCII string: "ENABLED" or "DISABLED."

FAN:ON/OFF Turns the cooling fan on or off. For protection, the drive will turn the fan on when the heatsink temperature reaches approximately 50 degrees C, regardless of this setting.

FAULT? Requests the system fault status. The system responds with the ASCII string "FAULT" if there is a fault condition, otherwise it responds with "OK."

FLTQ? Lists all faults in a text display and indicates whether or not each fault is in a “FAULT” state or “OK”.

FLTA? Requests system fault status. The system responds with hexadecimal numbers in the form “XX YY”, indicating fault conditions.

The first word ("XX") is decoded as follows:

Bit	Meaning if Set
7 (MSB)	Reserved
6	Reserved
5	Reserved
4	Transformer Over-Temperature
3	Auxiliary #1 Fault
2	Logic Power Fault
1	Amplifier Over-Temperature
0	Reserved

The second word ("YY") is decoded as follows:

Bit	Meaning if Set
7 (MSB)	Reserved
6	Reserved
5	Reserved
4	Reserved
3	Over Speed Fault
2	Main Air Fault
1	Clamp Air Pressure Fault
0	Bearing Air Pressure Fault

For Example: If FLTA? returns “02 08”, that would be decoded to mean “Amp Over-Temp” and “Over Speed” faults occurred.

FLT? Same as the FLTA? command, except that raw binary data is returned instead of hexadecimal numbers.

FLTQREAD? Returns the first value of a queue of stored values from previous faults. The returned values are interpreted just as those returned by the FLT? Command. This command allows for a review of faults, which occur and clear before a standard FLT? command can be issued.

FLTQREADQ Same as FLTQREAD? Except the result is typed out in plain text.

HEATSINKT Displays the amplifier heat sink temperature, in degrees Celsius (Centigrade).

ID? Requests the controller to send back its identification information as an ASCII string. The system responds with something similar to:

LA-2000;Model: G2;Serial: 6600000;Version: 3.00 ;Configuration: B0000

"Serial:" indicates the drive serial number (also found on the drive serial label), "Version:" displays the installed software version number and "Configuration:" shows the amplifier configuration code (also found on the drive serial label).

IPLIST Displays the network IP address and other network information.

LPR? Queries the logic power fault status.

MENU Provides a list of valid commands. Note: Some commands are valid only in configuration mode.

MOTORPERIODERROR? Used only in clocks per rev mode with the auxiliary PLL option. Responds with the number of counts of error for one motor revolution.

POS:XXXXX Used on drives with the positioner option to go to a specified position, specified in counts. *Entering POS:CAP will go to the position that was captured with the hardware position capture.* SC2, Pin 10 is, by default, configured to capture an actual position when pulled to logic level low.

POSCAP? Responds with the hardware captured position. SC2, Pin 10 is, by default, configured to capture an actual position when pulled to logic level low.

POSGAINS? Lists all gain settings for the positioner option.

POSMODE:X POSMODE:1 enables positioning mode. POSMODE:0 disables positioning mode and returns to the operating mode that was used before entering positioning mode (FLL, analog torque, etc.). Requires positioner option.

POSQ? Reports the actual motor position in counts, relative to the index.

RAMPIN Activates the acceleration ramping as set by the ACCEL:XXXXX and DECEL:XXXXX commands. The default power-up state is RAMPIN. Ramping can be used with either internal or external reference FLL velocity control.

RAMPOUT Deactivates the acceleration ramping as set by the ACCEL:XXXXX and DECEL:XXXXX commands. If set to RAMPOUT, the motor will accelerate at the maximum rate possible, dependent on inertia, load, etc. in an open loop manner. This mode should also be used if the drive is in external FLL mode and the command frequency is ramped in a controlled manner by customer supplied electronics, to provide a desired speed profile, such as a constant linear velocity spiral.

READY? Requests the ready status (whether the drive can be enabled). The system responds with the ASCII string "YES" if ready, otherwise "NO."

RELAYRUN Used to close the motor output relays to allow the motor to run, if they have been opened using the RELAYSTOP command. This command would typically only be used if optional braking resistors are installed.

RELAYSTOP Disables the drive and opens the motor output relays. This also activates optional motor braking resistors if the drive is equipped. This command would typically only be used if the braking resistors are installed. If braking resistors are not installed, the motor will “free-wheel” if this command is issued.

RUN Enables the controller and commands the motor to accelerate to the requested speed. Same as the ENABLE command.

SETZEROPOS Enters encoder set-up mode. This command is used during mechanical adjustment of the encoder index in encoder-only systems (TYPE:07).

SPEED:XXXXX Used in FLL speed controlled systems using the internal synthesizer frequency reference to set the requested speed to XXXXX RPM.

SPD:XXXXX Same as the SPEED:XXXXX command.

SPEED? Returns the value of the SPEED:XXXXX command.

SPD? Requests the current speed, in RPM. The system responds with an ASCII string "XXXXX", where X is a digit from 0 to 9.

STATQ? Requests system status in a text format.

STATA? Requests system status. The system responds with hexadecimal numbers in the form "XX YY", indicating current status. *NOTE: 'Ramping' status only applies during deceleration and acceleration, and 'In Window' status applies during* external FLL mode, *only* when speed ramping is active.

The first word ("XX") is decoded as follows

Bit	Meaning if Set
7 (MSB)	System Fault
6	Reserved
5	Direction Status, 1 = CCW, 0 = CW
4	Motor at Speed, 1 = at speed
3	Speed = 0
2	Reserved
1	System Ready
0	System Enabled

The second word ("YY") is decoded as follows

Bit	Meaning if Set
7 (MSB)	Reserved
6	Energy Foldback
5	Temperature Foldback
4	Reserved
3	Ramping, 1= Up, 0=Down
2	In Window (See 'winlimit' command)
1	Reserved
0	Chuck is Clamped

STAT? Same as the STATA? command, except that raw binary data is returned instead of hexadecimal numbers.

STOP Commands the motor to decelerate to zero speed and the controller to disable when the motor speed is less than the stop speed. Adjust the disable speed threshold with the STOPS:XXXXX command.

STOPLOCK Brings the motor to a controlled stop and then locks it in position. Requires using UNLOCK command to resume normal operation. LOCKMODE must be set to '1'.

STOPUNCLAMP Performs a STOP and UNCLAMP in sequence.

TORQUE:XXX Sets the torque limit to XXX percent of full scale. XXX is a number from 1 to 100. The torque limit circuit can optionally be configured by MCS to function as a torque scaling circuit. This is desirable for analog torque control systems as it can provide a means of programming the current scaling. Consult MCS for more information.

TORQ:XXX Same as the TORQUE:XXX command.

TORQUE? Returns the value of the TORQUE:XXX command.

UNCLAMP Causes the motor or spindle chuck to open or unclamp the disk or work piece. Sending this command while the motor or spindle is rotating results in an error.

UNLOCK Releases the lock on the motor caused by issuing the STOPLOCK command. The motor will now be in a disabled state (Internal Enable systems) or resume external control (Torque or External Enable systems). UNLOCK or UNLOCKRUN must be used to clear a STOPLOCK before normal operation may resume!

UNLOCKRUN Same as UNLOCK, except also executes a run after unlocking.

ZERO? Requests the zero speed status. The system responds with the ASCII string "YES" if the system speed is zero and "NO" if the motor is still turning.

5.1.2.2 Commands for Configuration Mode

In order for configuration changes to take effect every time the controller is powered up, be sure to use the WRITE command to save the configuration information. After entering and executing a valid command in configuration mode, the controller will respond with 'In Configuration State'. After this response, the drive is ready to accept the next command.

ANALOGIN Configures the drive for analog torque mode. The torque request is external, as is the enable signal. *NOTE: This command is not used in units with the optional analog **VELOCITY** control loop.*

ANALOGOUT Returns the drive to velocity control mode. The torque request is then generated by the FLL or velocity loop. The enable/disable control is also returned to the RS-232 or communication interface.

ANGLE:XXX Sets the motor commutation angle from 0 to 359 in electrical degrees (See section 4.4).

AUXPLL:IN Activates the auxiliary PLL option, if equipped. Used to multiply up a single pulse per rev command to the required encoder rate command frequency.

AUXPLL:OUT De-activates the optional auxiliary PLL option.

CLOCKSPERREV:XXXXXX Used to enter the master clock rate, in clocks per revolution, on drives equipped with the high frequency PECL input and auxiliary PLL option. The high frequency PECL input is then divided by this value to generate a one pulse per rev signal.

CLOCKSPERREVMODE:ON/OFF Used to enable or disable the high speed clock frequency divider. This command is only used with the high frequency PECL input and auxiliary PLL option.

DISABLEHH Disables optional handheld terminal. Handheld terminal must be disabled if the positioner option is installed.

DISFAULTS:WXYZ Enables or disables certain faults based on the hex numbers WXYZ. The hex numbers WXYZ are transmitted to the controller as characters (0-9, A-F) using standard hex notation.

W corresponds to:

Weight	Meaning
8	Reserved
4	Reserved

2	Reserved
1	Reserved

X corresponds to:

Weight	Meaning
8	Auxiliary Fault
4	Reserved
2	Reserved
1	Reserved

Y corresponds to:

Weight	Meaning
8	Reserved
4	Reserved
2	Reserved
1	Reserved

Z corresponds to:

Weight	Meaning
8	Over Speed
4	Main air Fault
2	Clamp Air Pressure Fault
1	Bearing Air Pressure Fault

To disable a fault, add up the weights of the faults you want to disable for each of the four hexadecimal characters. Check System Configuration (Section 10) for the faults that were installed when unit was shipped.

DNSADDR:xxx.yyy.zzz.xyz Enters the Domain Name Server IP address for the Ethernet network in dotted decimal format.

ENABLEHH Enables the optional handheld terminal. The handheld terminal must be disabled if the positioner option is installed.

ENCODERCOUNT:XXXXX Sets the encoder line count.

ENCODERTYPE:X Selects whether the encoder is single-ended or differential. If X is an S then the drive is in single-ended mode, and if X is a D the drive will be configured for differential inputs.

EXTEN External enable mode. Causes the drive to be enabled using the external enable signal on SC2, pin 6. A TTL low will enable the amplifier. If FLL

speed control is used, the amplifier will also use the external direction input on SC2, pin 13 to determine what direction to run. A TTL low on the direction input selects CW rotation, a TTL high, or floating, selects CCW.

EXIT Exits from the Configuration mode back to the Normal mode.

FEEDDIV:X Used to add a divisor to the FLL velocity control loop feedback when in external FLL mode. This is used if the maximum frequency available to the LA2000 is limited. Setting FEEDDIV to anything other than 1 allows a higher speed for a given input frequency, but reduces performance, particularly low speed jitter. Choices are 1, 2, 4, and 8, with a default of 1.

FLLEXTERNAL Sets the FLL request frequency input to the optional BNC jack or BDC compatibility connector. The relationship of input frequency to motor speed is given in Section 7.1.1 (FLL Velocity Loop Control).

FLLGAIN:X Used to adjust the proportional gain of the digital portion of the FLL loop. Valid range is -3 to 3, expressed in powers of two to result in gain settings from 1/8 to 8. The default and recommended setting is 0 for unity digital gain.

FLLINTERNAL Sets the FLL request frequency input to the internal synthesizer.

GWADDR:xxx.yyy.zzz.xyz Enters the network gateway address in dotted decimal format.

INTEN Internal enable mode. Causes the system to accept enable and direction commands over the RS232 or communication interface as opposed to the external TTL interface.

IPADDR:xxx.yyy.zzz.xyz Sets the IP address of the drive, in dotted decimal format.

JERK:xxxx Enters the Jerk setting for s-curve positioning with the positioner option. Units are RPM / second squared.

LOCKMODE LOCKMODE1 enables stop and lock operation (see STOPLOCK command). LOCKMODE0 disables stop and lock operation which is required for other options, such as angle offset.

MINSPDIN Configures the drive for a special mode that is applicable only when the drive is in external frequency input mode. The command allows the user to use the stop speed to set up a minimum speed at which the drive will enable. If the external frequency is above the stop speed, the drive will enable and operate normally; frequencies below this speed will stop the drive.

MINSPDOUT Configures the drive for normal operation with external frequency.

OFFSET:XX Sets a direction dependent amount of angle offset from 0 to 99 degrees to be added or subtracted to the base motor commutation angle as input with the ANGLE:XXX command. OFFSET is added to ANGLE for CW motor rotation and subtracted from ANGLE for CCW motor rotation (See section 4.2.2). Requires disabling of Stop and Lock operation (LOCKMODE0).

OVERSPEED:XXXXX Sets the speed in RPM at which an over speed fault will occur.

POLES:XX Sets the motor pole count.

POSACCEL:XXXXX Sets the acceleration rate (in RPM / second) for positioning mode, if equipped with the positioner option.

POSDECEL:XXXXX Sets the deceleration rate (in RPM / second) for positioning mode, if equipped with the positioner option.

POSDGAIN:XXXX Enters the derivative gain for the positioner option.

POSDSAMPLE:XXXX Enters the derivative sample time for the positioner option.

POSIGAIN:XXXX Enters the integral gain for the positioner option.

POSILGAIN:XXXX Enters the integration limit for the positioner option.

POSMAXVEL:XXXXX Enters the maximum velocity for positioning mode, if equipped with the positioner option.

POSPGAIN:XXXX Enters the proportional gain for the positioner option.

READ Retrieves old configuration data and wipes out any new configuration data.

SAVE Writes the new values of the configuration to the EEPROM. Use this before exiting the Configuration mode. The unit must be powered down and powered back up again for the new configuration to be valid. Same as the WRITE command. All changes made to any operating or setup parameters must be saved before turning off power or else they will revert to their last saved settings.

STARTS:XXXXX Sets the speed at which the motor controller enables when in minimum speed detection mode (MINSPDIN).

STOPS:XXXXX Sets the speed at which the motor controller disables after a receiving a STOP command. XXXXX is the motor speed in RPM. The default value is 30 RPM.

SUBMASK:xxx.yyy.zzz.xyz Enters the subnet mask for the Ethernet network in dotted decimal format.

TOPSPEED:XXXXX Sets the top selectable speed for the motor.

TYPE:XX Selects type of commutation. If you are using a motor with an encoder and Hall Effect devices, this number is 06. If you are using a motor with only an encoder, the commutation type is 07.

CAUTION: It is important that this number is correct. The amplifier employs a different commutation scheme for a motor with Hall Effect devices.

ATTENTION : il est important que ce nombre soit correct. L'amplificateur utilise un schéma de commutation différent pour les dispositifs à effet Hall.

WINLIMIT:XX Sets the window for speed ramping in external FLL mode. Entered in tenths of a percent. I.E., if WINLIMIT is set to 30, a change in the reference frequency of 3% or more will cause the drive to perform a controlled ramp to the new velocity, and a step of less than 3% will cause a step response in the velocity. WINLIMIT has no effect in internal FLL mode or if ramping is turned off.

WRITE Same as SAVE.

5.2 Hardware Interface

NOTE: For operation of communications controlled systems, see section 6.2.1.

5.2.1 TTL Interface

The LA2000 Gen. 2 has the ability to accept external direction, enable, and frequency request signals. This allows for a very simple user interface to the drive. In order to configure the drive for using the external enable and direction signals, use the **EXTEN** command in the configuration mode. If the drive is also configured for external frequency operation (**FLLEXTERNAL**) then the speed will correspond to the external frequency input (see Section 7.1.1 FLL Velocity Control Loop). If the internal frequency synthesizer is selected (**FLLINTERNAL**) the motor controller will go to whatever speed is the power-up default. To enable the drive pull SC2, pin 6 to logic common. An open or logic 1 (+5V) on SC2, pin 6 will disable the drive. A logic 1 (+5V), or open, on SC2, pin 13 corresponds to CCW rotation, while a 0, or logic common, will cause CW rotation. On drives using the STOPLOCK command and external enable input, the enable line must be grounded during the entire time the motor is in the locked condition, or else the controller will disable. This is to provide an emergency way to disable the amplifier without a software command. If the drive does become disabled, issue the UNLOCK command prior to re-enabling, otherwise undesired operation may occur.

5.2.2 Analog Interface (Analog Torque mode control)

The analog interface option allows the drive to be interfaced through a +/- 10V single-ended analog signal. Control loops must be closed external to the drive. The input command voltage corresponds to the amplitude level of the current in the motor. The default scaling is 1V = 1.5A peak. If the drive is equipped with the optional SCALE potentiometer, the scaling can be adjusted to produce a lower current for a given command voltage. If the drive has been optionally configured such that the Torque Limit circuitry provides a current scaling rather than a limit, the **TORQUE** command can be used to remotely reprogram the drive's current scaling. Positive signals cause CCW rotation, and negative signals cause CW rotation. **ANALOGIN** is the command which puts the drive into this mode. The drive is enabled through SC2, pin 6, as above, and the torque command is input at SC, pin 5.

5.2.3 Analog Interface (Analog Velocity mode control)

An analog velocity loop option is available to enable speed control through a +/- 10V single-ended analog signal. This option must be installed at MCS. The amplifier must be configured using the **ANALOGOUT** and **EXTEN** commands when velocity control is desired (as opposed to torque mode control). The drive is enabled through SC2, pin 6, as above, and the velocity command is input at SC2, pin 5. Contact MCS for more information on this option if required.

5.3 Error Messages And Their Meanings

When entering commands, the system may not be able to process the command for various reasons. The table below describes the error codes and the probable cause of the error.

Error code	Error message	Possible Cause
0?	Unrecognized command	Spelling of command incorrect
2?	Invalid request	Input data out of acceptable range
3?	Unable to change setup	Drive needs to be disabled
6?	Command string too long	

Part 6

OPERATION

6.1 Power Up

WARNING: Before powering up for the first time, ensure that the system has been installed and wired correctly. Refer to Part 3: Installation.

AVERTISSEMENT : Avant la première mise sous tension, s'assurer que le système a été installé et câblé correctement. Consulter la partie 3 : Installation.

CAUTION: Improper installation may cause damage to the unit.

ATTENTION : Une installation incorrecte peut endommager l'unité.

Applying power sets the internal scale factors and auxiliary outputs to the power-up configuration. The drive is not ready for operation until approximately 2-3 seconds have elapsed. The configuration is dependent on the default settings for your system. You are able to change the default Speed, Acceleration, Torque, Direction, and other parameter values by using the **WRITE** command in configuration mode. See Section 5.1.2 Command Summary.

In encoder-only equipped systems, when the unit is enabled after power-up, it goes into an encoder initialization state. In this state, the motor is locked in a known position to initialize the position counter. This state lasts a few seconds, after which the commutation logic automatically goes into its normal operating mode.

CAUTION: After the lockup state the motor could turn in the wrong direction momentarily. If this is not allowable in the system, MCS suggests using Hall Effect devices along with the encoder to ensure proper startup.

ATTENTION : Après un blocage, le moteur peut temporairement tourner dans le mauvais sens. Si le système ne le permet pas, MCS recommande l'utilisation de dispositifs à effet Hall avec le codeur afin de garantir un démarrage correct.

This does not apply to systems using Hall Effects, since absolute position is always known.

6.2 Normal Operation

6.2.1 Communications Controlled Systems

After the amplifier has powered up, and the communications interface has transmitted "Configuration Complete" (approximately 2-3 seconds), it is ready to accept commands. Refer to Section 5.1.2 Command Summary. Input a speed (**SPEED:XXXXX**) and direction (**CW** or **CCW**) command, followed by a **RUN** command in order to start motor rotation.

Under normal operation, the amplifier can be in either an Enabled, a Stop, or a Disabled state. When Enabled, the system is in servo and the amplifier is controlling motor currents in such a way as to hold the motor at or accelerate it to its set speed.

When a **STOP** command is issued, the motor is commanded to decelerate to the stop speed (see **STOPS:XXXXX** command description) and then disable. If the motor kicks back in the wrong direction at the end of a stop, increase the stop speed. If the motor spins down too long, decrease the stop speed.

When in the Disabled state, the amplifier is effectively commanding zero motor current, allowing the motor to spin freely. In this state, the amplifier does not transfer power to or from the motor.

6.2.2 Interlocks and Faults

Interlock circuits continually monitor certain conditions external and internal to the unit. The interlocks disable the amplifier if these conditions stray outside of specified limits. In addition to the standard interlocks, the user can configure auxiliary inputs to monitor specific external conditions. Those conditions that cause the interlocks to disable the amplifier are called FAULT conditions. After receiving a fault condition, the LA2000 will disable or stop and enter a FAULT state.

The FAULT state is latching: the unit will stay in this state, even after the removal of the fault-causing condition. While in the FAULT state, the LA2000 will not accept a RUN or ENABLE command until a **STOP** or **DISABLE** command is issued. If, after a **STOP** or **DISABLE** command, the amplifier is still in FAULT mode, the fault is still present in the system.

There are two types of interlocks, internal and external. Internal interlocks are those protecting the motor controller. External interlocks are those related to the user's equipment and are connected to the drive through the SC2 connector. All interrupts are active high, which means that for a no-fault condition there must be 0V (logic common) at the input of the controller. Unused interlocks can be disabled by connecting them to common or using the "**DISFAULTS:WXYZ**" command (see Section 5.1.2.2 Commands for the Configuration Mode). The following table shows the pin outs of the interlocks and their functions.

Interlock	Pin	Function
Auxiliary Interlock	SC2-7	Disables the controller
Main Air Sense	SC2-14	Stops the controller
Bearing Air Sense	SC2-18	Stops the controller
Clamp Air Sense	SC2-19	Disables the controller
Amp Overtemp	Internal	Disables the controller
Logic Power Fault	Internal	Disables the controller
Transformer Overtemp	Internal	Disables the controller

NOTE: Logic Common is available on SC2, pins 9 and 25. Analog Ground is available on SC2, pin 8.

Auxiliary Interlock: The normal use for this interlock is to run wires from pin 7 and logic common (or analog ground) out along any cable connected to SC2 and connect the wires after the last connector. This will cause the system to fault if the cable becomes disconnected or severed. This interlock is also compatible with a PTC motor thermistor, or a normally closed thermal switch, if the motor is equipped with this type of over temperature detector.

Main Air Sense, Bearing Air Sense, and Clamp Air Sense: These are all customer configurable interlocks. If not used, they may be tied to logic common or disabled through the "**DISFAULTS:WXYZ**" command. Note: The Clamp Air Sense input will not create a fault while the amplifier is disabled, so that the chuck can be unclamped without creating a fault condition. The Clamp Air Sense input must be driven low prior to enabling the amplifier, otherwise a fault condition will result.

The amplifier internal faults are as follows:

Amp Overtemp - This is an internal fault, which will disable the controller if the temperature on the heatsink reaches 80°C. If this fault occurs, verify that the fan inlet or outlet is not obstructed and that the ambient temperature does not exceed 40°C.

Logic Power Fault - This fault occurs if the internal logic voltages exceed their limits.

Transformer Overtemp - This fault disables the amplifier if the transformer reaches approximately 120 °C.

Overspeed – This fault occurs when the motor speed exceeds the overspeed threshold (see **OVERSPEED:XXXXX** command).

Part 7

THEORY OF OPERATION

The amplifier can be thought of as consisting of two sections: control and power. The power section channels energy from the power input to the motor; the control section directs the power. These sections are further explained below.

7.1 Control Section

See Drawing #1405190, Control Level Schematic for more information.

7.1.1 FLL Velocity Control Loop

The Frequency Lock Velocity Control provides extremely accurate speed control using a combination of frequency and phase lock methods. Frequency and phase comparisons between a reference pulse-train and a feedback pulse-train result in internal command voltages that control the motor speed. The Frequency Lock Velocity Control generates a torque command voltage that is proportional to the difference between the two frequencies, causing the motor to accelerate or decelerate until the two frequencies are equal.

In most systems that use the Frequency Lock Velocity Control, incremental encoders are used to generate the feedback pulse-train. The reference pulse-train is generated by either an internal frequency synthesizer or an external TTL pulse-train. The external reference is input through an optional BNC connector or the optional BDC compatibility connector located on the front of the controller. The selection of the internal synthesizer or external input is made by the **FLLINTERNAL** and **FLLEXTERNAL** commands. *Note: Systems equipped with and using the Auxiliary PLL option should be set to FLLINTERNAL even though the command signal is an external pulse train.*

When using the external FLL mode, the **FEEDDIV** command allows some flexibility if the maximum frequency available from the external circuitry is limited. Using a value other than the default (1) divides down the feedback pulse train (by 2, 4, or 8 with a setting of 2, 4, or 8, respectively). This lowers the required command frequency for a given motor speed, but decreases performance, particularly low speed jitter. The **FEEDDIV** setting can be viewed with the **DUMP4** command.

When using an external reference frequency, the formula for the frequency is f = (speed request in RPM * encoder line count) / (FEEDDIV * 60 Hz). Example: The external reference frequency for a system with FEEDDIV = 1, using a 1024 line encoder and rotating at 3600 RPM is 61.440 kHz.

In systems configured for Analog Torque control, the FLL Velocity Control is bypassed to allow an external controller to close the loop.

7.1.2 Commutation Section

The LA2000 is a three phase drive for sinusoidally wound DC brushless motors. This means that the voltage generated across each phase by turning the rotor at a constant speed has a sinusoidal waveform. The magnitude of the generated voltage is proportional to the angular velocity of the rotor. Phase V and phase U voltages lag phase W voltage by 120 and 240 electrical degrees, respectively. In order to develop constant torque from the motor, sinusoidal currents must be injected into each motor winding in phase with the generated voltages. For this, the angular position of the rotor must be known at all times. The LA2000 determines the rotor position by converting the output signals of an encoder to a digital word that represents the absolute rotor position. This word is then converted to three phase words that are each multiplied with a velocity error (or torque command) signal to generate the three sinusoidal current request signals.

NOTE: Units equipped with the MCS-installed Sine/Sine+120 option use customer-supplied external commutation for the W and V phases. The third phase is generated internally.

7.1.3 Motor Phase Current Control Loop Section

The current control loops compare the three phase current requests from the velocity loop and commutation section with the actual motor phase currents and generate three current error signals that request output voltage from the power stage.

7.2 Power Section

The power section consists of the Main Power Supply and the Power Amplifier Stage.

The Main Power Supply is a transformer-isolated, full-wave rectified, unregulated, bipolar DC power supply. It provides a source of power for the three motor output phases.

Each motor phase also has its own amplifier stage. These electrically quiet, linear power stages consist of level-shifting circuitry and power semiconductor devices, which amplify the current error signals. The voltage that is applied to the motor terminals induces currents, which generate torque and motor rotation.

Part 8

SERVICING

Servicing procedures are not recommended. Do not attempt to service without consulting with MCS first.

WARNING: Dangerous voltages exist at several places within the enclosure. Disconnect power before and during any disassembly or servicing. Only qualified personnel should service this product.

ATTENTION : Des tensions dangereuses existent à différents emplacements du site. Couper l'alimentation avant et pendant toute manipulation ou toute opération d'entretien. Seul du personnel qualifié peut assurer l'entretien de ce produit.

8.1 Maintenance

LA2000 motor controllers do not require regular maintenance. However, cooling fans and heatsink fins should be inspected for dust accumulation, which interferes with the air-cooling system. Dust can be removed from the LA using a clean pressurized (less than 40psi) air stream. The inspection schedule will depend on the amount of dust in the location of the motor controller.

8.2 Troubleshooting

The purpose of this section is to provide a guide for identifying problems related to installation, adjustment, or application of the LA2000 motor controller. The guide is not intended as a service manual for the repair of damaged components. Service procedures should not be attempted without first consulting with MCS.

Nothing happens when the power switch is turned on
Problem No power to the LA2000 Solution Be sure that one end of the power cord is plugged into the rear panel receptacle and that the other end is plugged into an appropriate active outlet.
Problem Fuse is blown Solution Disconnect the power to the LA2000 and remove the fuse from the power entry module. Test the fuse for continuity and replace it if there is none. Check external wiring, specifically the motor phase outputs. When the controller blows fuses it usually means that something is shorted out, or the Power Entry Module voltage setting is incorrect. The replacement must have the same current and voltage rating as the fuse that was removed.

No serial (RS232) communications
Problem Incorrect communications parameters Solution Verify that the communication parameter settings on the host PC are: a) 8 data bits, b) 1 stop bit, and c) no parity. Also confirm that the baud rate setting on the host matches that of the LA2000. The LA2000 does not use handshaking.
Problem Receive and transmit lines reversed on the communications cable Solution Reverse the signals at pins 2 and 3 on the LA2000 side of the cable.

Logic Power Fault
Problem The internal logic power supplies are outside of specification Solution Check all external wiring and make sure that there are no excessive loads on any of the logic power outputs.

Amp Overtemp Fault
Problem The amplifier heat sink has exceeded a high temperature threshold Solution If the amplifier has recently faulted, determine whether the air exiting from the rear of the LA2000 is hot or whether it has an unusual smell. At the same time, verify that the cooling fan is working and unobstructed. Disable the LA2000 and allow the amplifier to cool. Verify that the motor commutation was adjusted correctly (see Section 4.4), and that the motor turns smoothly when the LA2000 is enabled

The LA2000 enables but the motor does not turn
Problem Commanded speed is zero Solution See section 5.1.2 and make sure that you have entered a non-zero speed request. The default speed request is zero.

Problem The LA2000 is still in the encoder setup state Solution The LA2000 is in a setup state for a few seconds after it has been enabled for the first time after power-up. During the setup state the motor locks into a position and does not rotate. The setup state can also be entered indefinitely by entering the SETZEROPOS command. If in the encoder setup mode, enter the command CLEARZEROPOS to return to normal operation.
Problem The motor feedback device (encoder) is not wired to SC2 correctly Solution See Section 4.3 and verify connections to SC2.
Problem The commutation is not adjusted properly Solution Verify correct commutation adjustment (see Section 4.4).
Problem The motor leads are not wired properly Solution See Section 4.2 and verify the wiring to the motor.

LA2000 enables, but motor is locked up (shaft will not rotate, even by hand)
Problem The encoder line count or the pole count does not match the system requirements. Solution Set the encoder line count and motor pole count to the correct values for your system.
Problem The phase relationship on the encoder inputs is reversed Solution Check to see if the phase relationship between the encoder outputs is correct. The correct inputs to the amplifier are A leading B when the motor is turning in a clockwise direction.
Problem All three Hall Effect devices are not present Solution Check system wiring to be sure that all Hall Effect devices are present and switching. (Refer to section 4.3.3)

Part 9

SPECIFICATIONS

9.1 General

Fuse/Fusible: 115V: 10A, 250V
230V: 6A, 250V

Power Requirements: 120VAC, 10A or 240VAC, 6A (±10%)

Power Output: 15A peak sinewave (intermittent), 8A peak sinewave (continuous), 75V nominal bus voltage at continuous current rating.

Dimensions: Width: 7.25”
Height: 6.25”
Depth: 11” (not including optional mounting flange)
Weight: 22 lbs. nominal

Environmental: Temperature: 0°C to 40°C Ambient Air Temperature
Humidity: 5 to 80%, Non-Condensing

9.2 Connector Definitions

The connector pin definitions follow. Refer to the sections listed for further information about each connector and signal definitions.

9.2.1 SC-5: RS232 Serial Connector

[From Section 4.6]

Amp DE9 Female Connector	Signal Name	Connect To Terminal Standard Serial Port DE9	DB25	Serial Port Function
1	Ground	-	1	Shield
2	Receive	3	2	Transmit
3	Transmit	2	3	Receive
4	Handheld Term. RX	-	-	N/A
5	Ground	5	7	Ground
6	At Zero Speed	-	-	N/A
7	Handheld Term. TX	-	-	N/A
8	At Speed	-	-	N/A
9	+5V	-	-	N/A

9.2.2 SC-2: Commutation (Motor Feedback) Connector

[From Sections 4.3.1 through 4.3.2]

PIN #	ENCODER and HED
1	+5V (Red)* (250 mA MAX)
2	A Channel Input
3	B Channel Input
4	I Channel Input
5	External Analog (Torque or Velocity) Input
6	External Enable Input
7	Auxiliary Interlock: 0V = OK +5V = Fault
8	Analog Ground
9	Logic Common (Black)*
10	Configuration Specific Input **(See Note Below)
11	Clamp Output ***(See Note Below)
12	!I Channel Input
13	External Direction Input
14	Main Air Fault Input
15	H1 (Yellow)*
16	H2 (Green)*
17	H3 (White)*
18	Bearing Air Fault Input
19	Clamp Air Fault Input
20	!A Channel Input
21	!B Channel Input
22	-15V (125 mA MAX)
23	+15V (125 mA MAX)
24	Chassis Ground
25	Logic Common

*(MCS Motor Wire Colors are given in parentheses)
** Default use is POSITION CAPTURE. May have future functionality for other application-specific functions.
*** 0 V = clamp
*** +15 V = unclamp

9.2.3 Motor Power Connector

Mating Connector: Tyco/AMP P/N: 206044-1
Mating Pins: Tyco/AMP P/N: 66361-2 (14-18 AWG wire) or 66103-2 (20-24 AWG wire)

[From Section 4.2.1]

Pin #	3-LEAD MOTOR Phase Name
1	Phase W
6	Phase V
8	Phase U
14	GROUND

Part 10

LIST OF DRAWINGS

The drawings that are referenced in this section are located in the "pdfs" directory on this CDROM manual.

Outline and Mounting Drawing:

1405210 LA2000 Gen. 2 Outline, Mounting dimensions and Connector Locations

System Wiring Diagrams:

1405150 Connection Diagram for RS-232 Controlled Encoder Commutated Systems

Printed Circuit Board Drawing:

1405180 Control Card Component Layout

Control Level Schematic

1405190 LA2000 Gen. 2 Control Level Schematic

AVAILABLE OPTIONS (as of 1/5/10)

MCS may add additional options and features in the future. Contact MCS Sales Department for information on pricing of the following factory installed options:

BDC Compatibility - Includes the BDC compatibility connector and configuration settings compatible with the legacy BDC-0610 drive. An optional mounting flange is also available.

BNC I/O Connector - Includes BNC panel connectors for encoder and index outputs as well as the command frequency input.

Positioner - Includes a powerful motion processor to add position loop control to the drive. Control can be easily switched between positioning and other modes, such as FLL, as needed.

Analog Torque Control - Standard Feature, but specifying this option will include factory configuration for *software control of current scaling* and default configuration for torque control. Please specify whether the command is single-ended or differential.

Analog Velocity Control - Includes internal tach generation circuitry and an analog velocity loop to accept a +/- 10 V input proportional to velocity. Balance and Scale adjustment potentiometers are included.

Sine / Sine +120 Commutation - This option bypasses the LA2000's internal commutation circuitry for use with special applications or motion controllers that perform commutation. The user will input +/- 10V analog current request signals for two motor phases. The third phase is generated internally.

High Frequency PECL-level Command Input / AUX PLL – This option is application specific and provides a method of locking spindle speed to a "master clock". An additional connector is provided to accept a high frequency PECL (differential Positive Emitter Coupled Logic) level signal for frequency command at a programmable "master clock" rate. This signal is divided down to a once per revolution pulse. The once per revolution pulse is multiplied up using the auxiliary PLL to the encoder line rate for FLL velocity control. The connector also includes pins for an auxiliary analog input for a summing junction, analog outputs for velocity error before and after the summing junction, and a buffered TTL-level index signal output. This option is application specific and not available for all encoder counts and speed ranges.

Sinewave (Analog) Encoder Inputs - This option includes interface circuitry to connect a 1V pk-pk analog output encoder to the drive, instead of the standard digital encoder. This is useful if an encoder interpolator is required elsewhere in the system for customer supplied motion control or measurement electronics. It is also useful where EMI is a concern as analog output encoders eliminate fast rising edges.

Braking Resistors - Consult MCS if command-actuated resistive braking or emergency stopping in the event of a power failure is desired. The optional resistors are connected by relays between the motor phases when the "RELAYSTOP" command is issued or if AC power is lost.